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SELF-SELECTION BIAS MODEL: AN APPLICATION OF TWO-STAGE SWITCHING REGRESSION TO SFAS NO. 19.

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ABSTRAK

Banyak penelitian akuntansi yang melibatkan pemisahan sampel menjadi beberapa grup atas dasar metoda akuntansi. Kemudian peneliti membandingkan karakteristik antargrup dan menguji perbedaannya secara statistis dan regresional. Dalam memecah sampel menjadi beberapa grup, pada umumnya diasumsi bahwa dua sampel atau lebih diambil dari populasi yang homogenus dan penempatan observasi ke dalam grup dianngap terjadi secara random. Dengan asumsi tersebut bias seleksi (selection bias) *diabaikan sehingga dapat mengakibatkan estimasi lebih* (overestimation) *koefisien regresi pada salah satu grup sehingga simpulan dapat salah.*

Makalah ini menginvestigasi eksistensi dan relevansi bias seleksi dalam penelitian yang membandingkan dua grup atas dasar metoda akuntansi untuk kasus industri minyak dan gas bumi. Regresi berganti dua-tahap (two-stage switching regression) digunakan untuk menunjukkan adanya bias seleksi. Hasil penelitian menunjukkan bahwa terdapat bias seleksi dalam penggunaan regresi untuk mengukur pengaruh faktor-faktor ekonomik terhadap pengeluaran untuk eksplorasi. Pendekatan ordinary least square *(OLS) secara konsistem mengestimasi lebih* (overestimate) *koefisien-koefisien regressi untuk kedua grup terutama perusahaan yang menggunakan metoda kos penuh* (full cost).

Kata kunci: *pilihan metode akuntansi,kuadrat terkecil ordiner, regresi berganti dua-langkah, kos penuh, usaha berhasil, minyak dan gas bumi.*

INTRODUCTION

This paper addresses the issue of selection bias in the analyses of economic consequences of mandatory accounting changes. The self-selection bias analyses are based on the idea that individuals choose one of two accounting methods on the basis of expected benefits from adopting one method over the other. Therefore, an analysis of economic consequences of mandatory accounting changes that ignore firm characteristics influencing the choice of accounting method may result in biased estimates of parameters under the study.

Shehata (1991) uses the case of SFAS No. 2 to illustrate the effects of selection bias on parameters of economic consequences analysis model. In order to apply the procedure, accounting choice decision and research and development (R&D) investment decision models are developed with their explanatory variables. R&D investment decision model is used to represent economic consequence analysis (structural change in the spending behavior of switching firms). Using the unbiased (corrected) estimates of the research and development (R&D) behavior model, Shehata then examines structural changes in the R&D model after the implementation of SFAS No. 2 and measured the sensitivity of the results to self-selection bias. The method used to correct for self-selectivity is a two-stage switching regression procedure developed by Heckman (1976, 1979) and Lee (1976, 1978). This structural change analysis may result in unwarranted conclusions if latent variables (firms characteristics) that affect the selection of method by sample firms are not taken into account in the analysis. Accounting choice decision model is developed to represent potential latent variables and to measure their joint impact on the behavioral relationship so that the resulting bias in the sample firm can be accounted for in the structural analysis. The study indicates that selection bias exists in both the capitalizing and expensing groups as shown by systematic differences between the results of OLS and switching regression estimates. After controlling the effects of macroeconomic factors, the structural analysis indicates that there is a different effect of SFAS No. 2 on the R&D spending behavior of previous capitalizers.

Maddala (1991) points out that empirical examples on self-selection bias so far do not show any strong evidence of selection bias. Self-selection is assumed to exist because firms select one method over the other on the basis of perceived benefits. In other words, firms choose between accounting methods on the basis of their own characteristics and the relative advantages of each method. With regard to Shehata's study, Maddala argues that R&D expenditures do not have the interpretation of benefit and cannot be the criterion on the basis of which firms select a particular method. Maddala emphasizes that the estimates from OLS with and without the selectivity term included are basically the same. Furthermore, an examination of the estimated coefficient after correction for bias indicates that differences in the behavior persist even after the firms in one group are placed in another group. Therefore, the results suggest that there is no strong evidence for selection bias, thus an important assumption of the selection model is perhaps not valid and may need further investigation.

This paper will applies Shehata's model and procedures to the case of SFAS No.19. The objective of this paper to examine the relevance of selection bias and to corroborate the validity of Shehata's research findings. The discussion in this paper will be limited to the issue of existence of selection bias in typical accounting choice related studies. This paper will not further examine and test the impact of the bias on the parameters of structural changes model for the firms switching from full-cost to successful effort method mandated by SFAS No. 19.

SELECTION BIAS AND ITS IMPACT ON PARAMETER ESTIMATES

Studies on economic consequences of mandatory changes in accounting method usually require grouping of samples into two groups by the methods under the study and examining the behavior changes of the firms before and after switching to a mandatory method. The problem of selection bias arises whenever there is a non-random sampling in the grouping of sample firms. Selection bias refers to the bias in the estimates obtained by the usual procedures of estimation that ignore the non-randomness of the samples (Maddala 1991). Even though there is no difference in the impact on estimation methods, Maddala distinguishes self-selection bias from sample-selection bias. Self-selection bias occurs in the case where the non-randomness arises from researcher's choices whereas sample-selection bias occurs whenever the investigator designs the sample or imposes some restriction on the sample.

Shehata (1991) describes four sources of sample selection-bias and their effects on parameter estimates: self-selection, truncation, latent-variables and imposition of selection criteria. Economic consequences researches often suffer from self-selection bias because managers must choose one among alternative accounting methods and the choice of method is conditional upon the firm-specific characteristics. Truncation problem may arise as firms' characteristics change over time that managers voluntarily switch from one method to the other. Joint effect of latent variables on accounting method decision and economic consequence decision may result in violation of independence and zero expectation of error terms in the estimation model. Specifying certain criteria for selecting sample observations may result in selection bias because the selected sample is no longer random. Whatever the sources of the nonrandomness, using nonrandom data to estimate economic conesquence model may compound the parameters of interest with parameters of accounting selection model.

Several studies in economics and accounting were devoted to the issues of selection biases and remedial methods to overcome them. For example, Gronau (1974) examines the issue of selection bias in the study of wage rates. When comparison analysis of wages of different population groups (among other, male-female and white-nonwhite differential rates) is attempted, one should take into account the workers' different job strategy (by developing selection criteria function), otherwise a selection bias will result. Traditional empirical studies concerning labor-force participation, wages and earnings are based on the observed distribution while some part is not observed because some wage-offers are rejected by job-seekers as unacceptable. Therefore, the data do not represent the total population and selectivity bias will arise. Using search model as a criterion function to correct the bias, the study indicates that traditional measures underestimate the rate of return to human capital and its rate of depreciation when applied to married women. The measures also tend to overestimate the white-nonwhite wage differential, but tend to underestimate the differentials between males and females and between woman with and without young children. Indeed, this is the case of selection bias caused by truncation effect of data.

Similar study to overcome the effects of truncation of data was done by Lee (1978) who examined the differential wage rates between union and non-union workers. Different from traditional model, he employed selection bias model to take into consideration the factors that effect the choice of labor union (i.e., union initiation fees, tastes and other membership requirements). He found that unionism does have a significant effect in raising wage rates. However, the results of comparison between the traditional and adjusted method indicate that unadjusted method overestimate the wage differentials for female and young workers but underestimate wage rates of most experienced male workers. Furthermore, estimates of traditional method underestimate the effect of unionism in the highest union coverage category and overestimate the effect in the lowest union coverage category.

In the auditing area, Abdel-khalik (1990a) applied self-selection bias parameters estimated from switching regressions to evaluate directly the costs (benefits) of knowledge spillovers arising from purchasing management advisors services (MAS) from incumbent auditor. The study investigates the jointness (or synergy in a form of *knowledge spillovers*) of audit fee and demand for MAS to determine whether purchasing MAS from the incumbent auditor has a bearing on audit fees. The study is motivated by the idea that the presence of knowledge spillovers should at least prevent audit fees from being high because of resultant cost saving of providing joint products. Client should not pay higher cost for acquiring two products from one firm instead of two firms. Econometric analysis of the client's cost of selecting audit firm to provide MAS is used to evaluate the probability that a client will self-select into one of two choices: buying the services from the incumbent auditor or from other firms. For the client, the costs of buying the services are influenced by the client's own internal organizational structure and view of the external environment in which audit services are acquired. However, prior empirical evidence indicates that audit fees tend to be higher for clients buying two product from the same firm. This suggests the absence of economic synergy between MAS and audit services. Heckman-Lee method is applied to the analysis to detect and correct self-selection bias. The resulting evidence of the study fails to reject the null hypothesis that there is no impact of MAS characteristics on audit costs because the coefficients of self-selectivity variables (Mill's ratios) are not statistically significant. The result is consistent with prior evidence.

In another study examining three possible specification problems with the research on information content of earnings disclosure, Abdel Khalik (1990b) includes the significance of the self-selection bias resulting from endogenous partitioning of sample information into good and bad news. He believes that in most earnings studies, partitioning the sample into good and bad news portfolios brings about a self-selection bias because such partitioning is based on characteristics and attributes of the firm that should not be ignored in the analysis. In particular, the good/bad news classification is not independent of changes in expectations about production, financing and investment decisions of the firm so that special estimation techniques is required to take an account of the variables. Two-stage switching regression is applied to evaluate self-selection bias using a total of 763 announcements data (391 first-quarter and 372 second-quarter) of 98 sample firms taken from hard copies of *Value Line* from 1974 through 1978. The results of the study indicate that self-selection bias is statistically significant with the expected sign at $p < 0.10$ for the first quarter and at $p < 0.05$ for the second quarter.

Switching Regression Model

Whenever sample separation is involved in a study that requires estimation of behavioral relationships using a portion of data, ordinary least square (OLS) method usually is not appropriate because consistency property of the OLS is violated. This violation will result in biased estimates of parameter. Several methods are proposed to overcome the selection bias (see for example, Lee, Maddala, and Trost 1980, Lee 1983, Maddala 1991). Two stage switching regression model using probit analysis exemplified by Heckman (1979) is one of the popular models.

The general switching regression model contains two regimes described by a set of simultaneous equations as follows (Lee, Maddala, and Trost 1980):

$$I_i = Z_i\theta - \in_i \qquad (1)$$

$$C_1Y_{1i} + \beta_1X_{1i} = \in_{1i} \qquad \text{iff } I_i > 0 \qquad (2)$$

$$C_2Y_{2i} + \beta_2X_{1i} = \in_{2i} \qquad \text{iff } I_i \leq 0 \qquad (3)$$

In the equations, I_i is a vector of indicator variables. Y_{1i} and Y_{2i} are vectors of endogenous variables, Z_i is a vector of exogenous variables, C_1 and C_2 are constant (normally 1). $\in_{1i}$, $\in_{2i}$, and $\in_i$ are residual terms. θ, β_1 , and β_2 are parameters. For a particular application, as will be in this paper, it is assumed that the residual $\in_1$, $\in_2$, and $\in\epsilon$ have a multivariate normal distribution with mean vector zero and covariance matrix:

$$Cov(\in_1, \in_2, \in) = \begin{bmatrix} \delta_{11} & \delta_{12} & \delta_{1\in} \\ . & \delta_{22} & \delta_{2\in} \\ . & . & \delta_{\in} \end{bmatrix}$$

Equation (1) represents the selection criterion function. The values of I_i are usually not observable in the data set but what is known is whether $I_i > 0$ or $I_i \leq 0$. In economic consequence analysis, I_i is normalized into a two-element vector representing dummy variable, i.e, $I_i = 1$ if $I_i > 0$ and $I_i = 0$ otherwise. Forcing $I_i = 1$ is the same thing as assuming that the variance of $\in$ to be 1. The model than becomes a simultaneous equations model with the selectivity criterion of the probit type and can be expressed in regression format as follows:

$$I_i = Z_i\theta - \in_i \quad (4)$$

$$Y_{1i} = \beta_1 X_{1i} + \in_{1i} \qquad \text{iff } I_i > 0 \quad (5)$$

$$Y_{2i} = \beta_2 X_{2i} + \in_{2i} \qquad \text{iff } I_i \leq 0 \quad (6)$$

The OLS cannot be used to estimate equation (5) because $E(\in_{1i}) \neq 0$ due to the use of only a subset of data that meet the selection rule embodied in equation (4). The regression function for the subsample of equation (5) data can then be expressed as:

$$E(Y_{1i} \mid X_{1i}, \text{selection rule}) = \beta_1 X_{1i} + E(\in_{1i} \mid \text{selection rule})$$

Similarly, regression function for the subsample of equation (6) data can be expressed as:

$$E(Y_{2i} \mid X_{2i}, \text{selection rule}) = \beta_2 X_{2i} + E(\in_{2i} \mid \text{selection rule})$$

Incorporating the criterion function into the two regressions, the expected error terms can be stated as (Maddala 1991, Shehata 1991):

$$E(\in_{1i} \mid Y_{1i}, \text{selection rule}) = Z\ \sigma_{1\in} [\phi(Z_i\theta)]/[\Phi(Z_i\theta)] = Z\ \sigma_{1\in} W_{1i}$$

$$E(\in_{2i} \mid Y_{2i}, \text{selection rule}) = Z\ \sigma_{2\in} [\phi(Z_i\theta)]/[1\ Z\ \Phi(Z_i\theta)] = Z\ \sigma_{2\in} W_{2i}$$

W_{1i} and W_{2i} are variables known as Mills ratios or selectivity variables. Incorporating these variables into the regression equations to correct biases, the regression functions (5) and (6) can be rewritten as:

$$Y_{1i} = \beta_1 X_{1i} - \sigma_{1\in} W_{1i} + \omega_{1i} \quad (7)$$

$$Y_{2i} = \beta X_{1i} + \sigma_{2\in} W_{2i} + \omega_{2i} \quad (8)$$

In the above equations, ω_{1i} and ω_{2i} are now error terms with zero expectation. The procedure to estimate the parameters is described in Heckman (1979) and Maddala (1983). After the two behavior relations have been correctly estimated, test of bias can be done by calculating the difference between what the behavior of each firm would have been had it belonged to the other group and the behavior under the current group.

If the conditional expectation of each error term ($\in_{1i}$ and $\in_{2i}$) is zero, the regression function for each selected subsample is the same as the population regression function. In this case, OLS estimator may be used to estimate β on each selected subsample although the estimator may not be efficient.

For economic consequence analysis, Shehata points out that the two-stage regression methodology has several advantages compared with ordinary OLS method. First, it provides a means for consistently and efficiently estimating coefficients of models in the presence of selection bias. Second, it allows researchers to explicitly model and examine the relationship between the accounting choice decision and the related production-investment decision. Finally, it provides expectations of the likely economic consequences of proposed accounting changes prior to their adoption, which might provide useful input into the rule-making process. However, there are some cautions in applying this method (Maddala 1991). First, the error terms in final equation are heteroscedastic so that the estimator may not be efficient. Second, Mills ratios are generated regressors so that their standard errors are influenced by the method of estimation. Finally, multivariate normal distribution of error terms should be assumed.

APPLICATION OF SWITCHING REGRESSION ANALYSIS TO SFAS NO. 19

A financial Accounting Standards Board (FASB) Exposure Draft released on July 18, 1977 proposed to eliminate the "full cost" accounting method used by many oil and gas producing companies to account for exploration costs and recommended that all such companies be required to follow the "successful efforts" method. By the time the FASB Exposure Draft was released, full cost (FC) and successful efforts (SE) were the two basic methods used to account for oil and gas exploration costs. Companies had an option to select whatever method was appropriate for them. Under the full cost method, all exploratory costs are capitalized and these costs are amortized over the discovered reserves on a pro rata basis. On the other hand, under the successful efforts method only prediscovery costs that can be related directly to revenue producing wells are capitalized and the rest are expensed. On December 5, 1977, the FASB issued its statement No. 19 affirming the proposal announced in the Exposure Draft. In August 1978, the SEC decided that neither full costing nor successful efforts could be supported and ruled that a new method of accounting must be developed for the industry based on recognition of the value of discovered reserves.[1]

In fact, there had been a debate about the merits and consequences of the mandatory change in the accounting for exploration costs. The main argument of FC users was that a switch to the SE method would (a) substantially depress reported earnings and equity figures and (b) increase significantly the volatility of earnings over time (as compared with the smoother earnings series resulting from the FC capitalization process). On the other hand, the FASB and its supporters defended the proposed accounting changes by arguing that (a) the SE method is conceptually more adequate than the FC method; (b) uniformity of accounting for oil and gas explorations will eliminate the burden of inconsistency, noncomparability, and misunderstanding in the capital markets, and, thus, foster competition in capital allocation; and (c) many small independent producers have been using the SE method for a long time without apparent adverse effects on their ability to raise capital and to compete with the large producers (Lev 1979).

The full cost and successful efforts methods usually produce markedly different results. Full cost always yields higher book asset values than successful efforts. Net income is higher under full cost when drilling and exploration costs are sufficiently large relative to production, and is lower when this is not the case. Furthermore, the issue of which method produces higher variability of reported result depends upon certain firm characteristics (Malmquist 1990). In the case of SFAS No. 2, Shehata (1991) mentions the argument that the elimination of the deferral option might induce managers to alter their R&D investment decisions, thus producing undesirable economic consequences. The elimination of full cost as an acceptable method of accounting also brings about some undesirable economic consequences. For example, the ability of small producers to raise capital in the stock and money markets would be seriously inhibited, resulting in a cutback of new explorations and in a deterioration of the competitive position of independent oil and gas producers. Several

[1] SEC overruled this standard after hearings testimony from certain full cost adopters which felt that they would be disadvantaged by the mandatory method. This overruling does not affect the relevance of this paper since this paper will not examine the structural changes of exploration spending after involuntary switch if the standard were made effective.

other issues related to the mandated change are the conceptual adequacy of the FC and SE methods, its impact on managerial behavior (e.g., is it a disincentive to risk-taking in exploration?), the effect on competition in the oil and gas industry, the ability of FC firms to raise money in capital markets after the switch, and its impact on capital markets (Lev 1979).

To address these issues, several studies have been conducted. Lev (1979) examine whether the accounting change would adversely affect the equilibrium values of firms' equity security. The results of his study indicate that the release of the FASB Exposure Draft was associated with a downward revision of stock prices of oil and gas producers, particularly those using the FC method. Collins and Dent (1979) also find that the shares of oil and gas producing firms using the FC method suffered significant negative abnormal market return subsequent to the release of SFAS No. 19 Exposure Draft. Using the same data from Collins and Dent study, Collins, Rozeff and Dhaliwal (1981) examine the economic determinants of the market reaction to the mandatory change and find that the FASB's proposal had a measurable negative effect on the equity values of affected firms. Lilien and Pastena (1982) examine the determinants of intramethod choice. They show that economic incentives influence the choice of FC and SE methods. DeAngelo (1982) provides evidence that oil and gas companies whose financial statements were adversely affected by SFAS No. 19 increased the rate at which they changed auditors during the FC/SE controversy. Using the same data as used by Dyckman and Smith (1979) and Lev (1979), Lys investigates whether debt covenants are related to changes in firm value occurring with mandated accounting changes in the case of oil and gas accounting.

All the above studies involve sample data that consist of two groups (i.e., firms adopting FC method and firms adopting SE method). These studies implicitly assume that sample firms are drawn from a homogeneous population and are randomly assigned to the two groups and none of these studies applies the self-selection model. It can be argued that the sample firms in those studies self-select the method so that the observations are not randomly classified into two regimes. Shehata (1991) argues that if firms are not randomly assigned to the two samples, a potential self-selection bias may lead to unwarranted conclusion about the economic impact of that accounting change. This paper will examine if selection bias is present in the sample data underlying those mandated change studies.

Formulation of the Switching Regression Model

Because of similarity in the issue between mandatory change in SFAS No. 2 and SFAS No. 19, the same model can be developed for the case of mandatory accounting change in the oil and gas companies. For the SFAS No. 19 case, instead of R&D investment decision, exploration investment decision will be used to construct the behavioral model. The changes in the structure of exploration model after the mandated change measure the economic consequences of the implementation of SFAS No. 19.[2] Therefore, the switching regression model for the case of SFAS No. 19 can be developed as follows:

Let Z be a vector of exogenous variables representing firm characteristics that influence the choice between full-cost and successful efforts methods and let X be a vector of exogenous variables determining the exploration investment decision.[3] The equations that represent switching regression model may be expressed as follows:

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[2] Again, because the standard never became effective, the structural test is not performed in this paper. The focus of this paper is the detection of selection bias.

[3] The variables used in this paper and the underlying theories are discussed in the next section along with the construction of criterion and behavioral functions.

Accounting-choice decision model:

$$AC_i = Z_i\theta - \epsilon_i \tag{9}$$

where AC_i is a latent variable representing the firm's preference to use either full-cost method (AC=1) or successful efforts method (AC=0) to account for exploration cost.

Exploration investment decision models:

$$EPL_{Fi} = \beta_F X_{Fi} + \sigma_{F\epsilon}\left[-\frac{\phi(Z_i\theta)}{\Phi(Z_i\theta)}\right] + \omega_{Fi} \quad \text{...... (10)}$$

$$EPL_{Si} = \beta_S X_{Si} + \sigma_{F\epsilon}\left[\frac{\phi(Z_i\theta)}{1-\Phi(Z_i\theta)}\right] + \omega_{Si} \quad \text{........ (11)}$$

The statistical significance of the estimated coefficients of selectivity correction terms ($\sigma_{F\epsilon}$ and $\sigma_{S\epsilon}$) provides useful information about the extent to which the two decisions are interrelated. If accounting choice and exploration investment decisions are independent, then it is expected that mandatory change to successful efforts method should not induce managers of previous full-costers to alter their exploration spending behavior. Therefore, the null hypothesis of no association can then be expressed in terms of zero coefficient of selectivity variables (Mills ratios). To test the hypothesis, two-stage estimation procedure is performed as follows: (1) Equation 9 is estimated for the total sample using the probit analysis. The estimated value of ($Z_i\ \theta$) is then used to generate the Mills ratio for each sample observation, and (2) The selectivity correction terms are incorporated to the equation 10 and 11 and then both are estimated by OLS.[4]

[4] For more detailed procedure, see Heckman 1979 and Maddala 1983, 1991.

FIRM-CHARACTERISTICS AND EXPLORATION DECISION MODELS AND DATA

The fact that two accounting methods prevailed at the time the SFAS No. 19 Exposure Draft was released indicated that there were in fact differences in the characteristics and environments between firms adopting full cost and firms adopting successful efforts methods. Full cost adopters were the group that were greatly affected by the standard and hence they were in opposition to SFAS No. 19. Therefore, the fact that significant differences between companies using each accounting method was one of the primary arguments advanced by these companies to justify continued use of both methods. Four factors were considered to be the dimensions for the differentiation between nonmajor full cost and non major successful efforts companies are: (1) aggressiveness in exploration (2) the need for external capital, (3) size and (4) age. Deakin (1974) examined these four dimension by identifying seven discriminating variables to determine if the two groups of companies were in fact different. Those variables are: (1) average debt of explanatory wells, (2) number of exploration per revenues, (3) development wells/total wells, (4) debt/revenue, (5)capital expenditure/ revenue, (6) revenue and age of company in years. It is hypothesized that full cost and successful efforts companies can be distinguished on the basis of aggressiveness in exploration, perceived need for access to public markets, size and age of company, and relative extent of developing drilling. The hypotheses were tested by constructing multiple discriminant analysis (MDA). The analyses indicated that full cost companies are more aggressive in exploration, smaller, newer, more highly leveraged and spend more on capital expenditure per revenue dollar than do those in the successful efforts group. However, the test results indicated that only the differences in age, leverage and ratio of capital expenditures to revenues are statistically significant.

Malmquist (1990) studied the relationships between observable firm characteristics and the likelihood choice of selecting full cost or successful efforts method. The relationships were discussed under the economic theory of security underwriting, debt covenant monitoring, managerial compensation scheme and political costs. He believed that the manner in which these factors influence the choice of method has a bearing on the economic characteristics of firms. Five characteristics are examined to determine their significant impact on the choice of method: debt equity ratio, source of financing, firm size, proportion of resources devoted to drilling and exploration and proportion of resources devoted to producing. Empirical tests were performed for three cases of samples: (1) all firms, (2) all firms except pipelines and public utilities, and (3) all firms except pipeline, public utilities, and major oil and gas companies using 1985 end-year-date. Using logit model to test the hypothesized relationships he found that for each case sales, exploration cost, production volume and debt-equity ratio are significant variables and they have the predicted signs.

Lilien and Pastena (1982) examine the determinants of intramethod choice in the oil and gas industry (full cost versus successful efforts). Their analysis is based on the idea that the choice of method is guided by economic motivation of managers to optimize income under certain environmental factor, i.e., political pressure, contract compliance and uncertainty of exploration results. Different from other studies in this area, they consider jointly intramethod and intermethod in defining the maximization and minimization income. Firms are classified as either dual choice maximizers which were most motivated to maximize income or dual choice minimizer income, an economic model is constructed where choice is dependent variable and is defined in the context of intermethod choice, intramethod choice and the joint or dual choice of intermethod and intramethod policies. The model is then tested using probit, multiple discriminant and regression analyses. Explanatory variables are managerial motivation variables which consist of revenue as a political variable, age as a consistency variable, dry wells/total wells as a proxy for risk, and debt/shareholders' equity as a proxy for leverage. The test results indicate that revenue and age are positively associated with the choice of SE and policies which minimize cumulative income while leverage and risk variable (aggressiveness) are positively associated with the choice of FC policies which maximize income.

Construction of Criteria Function (Accounting Choice Model)

Based on the above discussion on the determinants of accounting choice and in line with the model developed by Shehata (1991) for the case of SFAS No.2, three variables are selected as explanatory variables for the criterion model in this paper. The significance of the variables as shown by the empirical work and the availability of data are reasons for the selection. Then variables and their hypothesized relationships with the dependent variable are described as follows:

1. Firm size: The political cost literature (Watts and Zimmerman 1978, Lilien & Pastena 1982, and Malmquist 1990) suggests that firms will tend to reduce their political cost by selecting policies that have an income-decreasing effect. Therefore, it is hypothesized that the larger the firm, the lesser the likelihood it will choose full cost.

2. Leverage: Contract-monitoring under the agency framework suggests that the higher the risk of breaking the debt covenants the more restrictive are the covenants. Income is a major element of accounting related-covenants that require higher figure for risky business. The higher the leverage, the higher the tendency of managers to increase income though the choice of income increasing method. The more a firm is highly leveraged, the greater the likelihood that the firm will select full cost (Malmquist 1990, Deakin 1979).

3. Aggressiveness: In the testimony before SEC, many of full cost adopters argued that they were more aggressive in exploration than their successful efforts counterparts. This suggest that they need relatively greater fund either from debt or equity market. They argued that smooth earnings and greater assets and equity values were necessary to obtain new capital (Deakin 1979). The aggressiveness suggest that full cost companies commit a greater proportion of their resources to exploration. This is consistent with the market/engineering risk argument proposed by Malmquist (1990). It is hypothesized then that the greater the proportion of a firm's resources devoted to exploration, the greater the likelihood the firm will choose full cost. On the other hand, the greater the proportion of a firm's resources devoted to producing the lesser the likelihood the firm will choose full cost. The production resources variable will be used in this criterion function because exploration resoures variable will be used as a dependent variable in the behavioral function. Table 1 describes the notation, expected sign and measurement of these variables.

Table 1. Operational Definition of Variables Included in the Model

Variables	*Predicted Sign*	*Definition*
Dependent:		
AC (accounting choice)		The accounting method selected to account for exploration costs. AC=1 if the firm uses full cost and AC=0 if the firm uses successful effort method. Classification is based on Malmquist's data (1990).
Explanatory:		
SZ (firm size)	-	Net sales as reported on the COMPUSTAT tapes.
LV (leverage)	+	The ratio of long-term debt to market value of equity (outstanding shares X closing price) as reported on the COMPUSTAT tapes.
AG (aggressiveness)	-	Oil and gas produced in millions BTU equivalents. The values of this variable were derived from the data as reported on Malmquist (1990).

Exploration Model

Because of the similarity in the nature of decision concerning the R&D and Exploration, some explanatory variables used by Shehata will be selected for the same reasons described by Shehata. These variables are:

1. Firm size: In general, larger firms are financially stronger than the smaller firms to undertake exploration project. It is expected that the larger the firm, the larger the exploration expenditures.

2. Cash flows: Riskiness of exploration activities can limit the possibility of external financing so that firms should rely on internal financing to support exploration projects. Therefore, the higher the cash flows generated by a firm, the greater the firm's commitment to risky explorations projects (Shehata 1991).

3. Capital expenditures: Companies normally make expenditures in both exploration and capital investment. Both type of expenditures may be competing or complementary depending on the type of a firm. This paper will examine if firm-characteristics make a difference in this spending behavior. In the case of R&D, Shehata assumes that R&D activities are alternative for the capital commitments made by the firm. Table 2 presents the definition (notation), expected sign and measurement of these variables.

Table 2. Operational Definition of Variables Included in the Model

Variable	*Predicted Sign*	*Definition*
Dependent:		
EX (exploration)		Total exploration cost for the year 1985. The values of this variable are derived from the data used in Malmquist (1990).
Explanatory:		
AT (firm size)	+	Total tangible assets as reported on the COMPUSTAT tapes.
CF (cash flows)	+	Cash flows generated in previous year and measured as the total of income before extraordinary items and depreciation and amortization. Data are taken from COMPUSTAT tapes.
CE (capital expenditures)	?	Total amount of capital expenditures incurred by the firm as reported on COMPUSTAT tapes.

With all the variables defined above, the two-stage switching model of equations (9), (10), and (11) can be expressed as follow:

$$AC_i = \theta_1 + \theta_2 SZ_i + \theta_3 LV_i + \theta_4 AG_i - \in_i \quad (12)$$

$$EX_{Fi} = \beta_{F1} + \beta_{F2}AT_{Fi} + \beta_{F3}CF_{Fi} + \beta_{F4}CE_{Fi} - \sigma_{F\in}W_{Fi} + \omega_{Fi} \quad \text{iff } AC_i > 0 \quad (13)$$

$$EX_{Si} = \beta_{S1} + \beta_{S2}AT_{Si} + \beta_{S2}CF_{Si} + \beta_{S3}CE_{Si} + \sigma_{S\in}W_{Si} + \omega_{Si} \quad \text{iff } AC_i \leq 0 \quad (14)$$

SAMPLE SELECTION AND DATA

The sample firms are selected from the list of companies identified by Malmquist (1990) for the period of 1985 (his list consists of 316 sample firms). The values of several variables (exploration and production) are derived from the Malmquist's data and the data on other variables are collected from COMPUSTAT tapes. CUSIP number from the Malmquist's list is used as a basis to extract data from CUMPUSTAT tapes for variables not in the Malmquist's list. Some firms are eliminated from the Malmquist's list because they tend to be those for which several variable values from COMPUSTAT data tapes are missing or they are not available in the tapes. The available sample of 187 firms is finally used in this paper. This sample represent 80 firms adopting full cost method and 107 firms adopting successful efforts method. Since structural test is not performed in this paper, control sample is not established. Summary statistics of variables for full-cost and successful efforts firms are presented in Table 3.

Table 3. Descriptive Statistics of the Variables for FC and SE Firms: Mean and Standard Deviation in 1985

Variable	*Full Cost*	*Successful Efforts*	*t-value*	*two-tail p-value*
n	80	107		
AC Equation:				
SZ	6042.36 (13888.26)	2513.78 (11437.51)	1.9034	0.0595
LV	0.9215 (0.9483)	1.5518 (3.4784)	-1.5766	0.1188
AG	2697.63 (6247.45)	888.62 (2463.59)	2.7269	0.0081
EXP Equation:				
EXP	2875.76 (6338.60)	1045.43 (301.91)	2.6177	0.0090
AT	5810.90 (11494.27)	2998.23 (11465.81)	1.6579	0.0980
CF	635.84 (1392.44)	218.48 (832.40)	2.5513	0.0110
CE	607.28 (1285.53)	300.05 (807.92)	2.0005	0.0463

The summary data show that full cost companies tend to be larger than successful efforts companies in terms of sales and assets. These facts seem to be contradictory with the hypothesized relationships. It should be noted that the hypothesis regarding the size is developed before the knowledge of the summary statistics to avoid a tendency of overfitting the model. Full cost companies have relatively lower leverage than do successful efforts companies. Relatively large production units of full cost companies indicate that the FC companies are more aggressive in production activities. Moreover, full cost firms have higher exploration and capital expenditures. In general, full cost and successful efforts firms are statistitically different in terms of size, aggresiveness, exploration expenditures, cash flows, and capital expenditures.

EMPIRICAL RESULTS

Table 4 reports the estimates of the switching regression model. The probit estimates of the accounting-choice equation are presented in panel A, and the OLS estimates of the exploration equations (corrected for self-selection bias) are reported in panels B and C for full cost and successful efforts samples, respectively. The models are estimated by OLS without weighting so that heteroscedasticity may present. It is assumed that the problem of heteroscedasticity does not affect the analysis results.

Table 4. Estimates of the Switching Regression Model

Variable	Coefficient	Standard Error	t-ratio (Chi-sqr)	Significance (Pr>Chi)
Panel A. Accpunting Choice Equation:				
Intercept	0.67061	0.13872	23.3676	0.0001
SZ	0.00019	0.00011	2.6741	0.0120
LV	0.03431	0.04776	0.5162	0.4725
AG	-0.00228	0.00054	17.6032	0.0001
Chi-squared: 188.39 (Pearson Chi-Square), p > 0.0483 Log-likelihood: -93.52 Cases correctly classified as full cost firms: 76.5% (n=80) Cases correctly classified as successful efforts firms: 87.5% (n=107)				
Panel B. EXP Equation (FC Sample):				
Intercept	33.5597	201.03184	4.5410	0.0001
AT	-0.0320	0.04995	-3.2280	0.0018
CF	2.1108	0.78347	0.7310	0.4673
CE	2.7791	0.77217	1.8660	0.0660
Selectivity variable	-1.8652	7.99450	-9.0410	0.0001
Adjusted R^2=0.9721 F=689.51 (p>0.0001)				
Panel C. EXP Equation (SE Sample):				
Intercept	57.1083	23.80120	2.3990	0.0182
AT	0.0403	0.04572	0.8890	0.3759
CF	2.0198	0.52674	3.8350	0.0002
CE	0.4958	0.49948	0.9930	0.3233
Selectivity variable	-8.8951	5.96019	-1.4920	0.1387
Adjusted R^2=0.7629 F=86.27 (p>0.0001)				

Panel A indicates that the classificatory power of the criterion function is sufficiently high (76.5% for full-costers and 87.% for successful efforts firms). Pearson statistic indicates that the overall explanatory power of the model is statistically significant (p>0.0483). Estimation using probit link produces similar values for the coefficients of explanatory variables also with statistically significant goodness-of-fit statistic. Therefore, the accounting-choice model has good overall explanatory power even though not all coefficients are statistically significant. The estimated coefficients of agressiveness and size variables are statistically significant. The sign of size coefficient, however, is not in the direction predicted. This implies that the political cost theory does not applies to oil and gas industry. In general, the firms that are more likely to prefer the full cost method are large and aggressive.

After incorporating selectivity variable in the model, the results of estimation indicate a quite different behavior between the two groups of firms with respect to exploration expenditure. Table 5 presents comparison of coefficients between full cost and successful efforts firms taken from Panel A and Panel B of Table 3.

Table 5. Comparison of Coefficients

Variable	Full Cost	Successful Efforts	Statistic of difference
AT	-0.0320*	0.0403	1.0663
CF	2.1108	2.0198*	0.1000
CE	2.7791	0.4958	2.6096*
Selectivity variable	-1.8652*	-8.8951	0.7290

Statistic of difference was determined using mean difference test by assuming that the coefficients were random variable drawn from independent population. Choi test can also be used. *Statistically significant at $p < 0.05$.

Statistically significant difference in one of the coefficients (CE) indicates that structurally the two equations are not equivalent. This means that the variables impact differently in each of the two groups of firms. The estimated coefficient of size in the full cost sample is negative and smaller than that in the successful efforts sample. While CF coefficient in the SE sample is statistically significant, it is not the case in the FC sample. The estimated coefficients of cash flow (CF) suggest that the availability of internally generated funds is important in explaining exploration variation for the SE firms, but not for the FC firms. The CE coefficient in the FC sample is larger and statistically significant compared to that in SE sample. For the FC sample, exploration funding decreases proportionately with firm size and increases with capital expenditure. Statistically significant difference in CE variable implies that capital investments are complementary decisions for the SE sample but they are independent of exploration decisions for the FC sample. The estimated coefficient of the selectivity variable for the FC sample is negative and statistically significant at less than 0.05 level. This result suggests that the average exploration expenditure for full cost firms, given the firm-specific characteristics, is likely to exceed what these firms would have spent under the successful method. However, this is not the case for SE firms which are unlikely to spend more on exploration under the successful than they would have spent under the full cost method. This supports the idea that the choice of method is not a random action by both groups of firms.

In summary, the exploration activities for FC firms are more associated with the size and the capital expenditure while for SE firms, the exploration activities are more determined by the level of available fund generated by previous operation. These results indicate that the two groups of firms are different in characteristics as well as in the structure of their exploration decisions. Therefore, it would not be correct to assume that the sample firms in the two groups are randomly selected from a homogeneous population.

For comparative purposes, the OLS estimates of the exploration equations without correction for self-selection bias and the corresponding estimates of the two-stage regression model are reported in Table 6.

Table 6. OLS Estimates of the Structural Regression Model

Variable	Coefficient, (Standard Error), t-value		Statistic of difference
	FC firms	SE Firms	
Ordinary LS:			
Intercept	33.5597	30.2010	
	(201.0318)	(15.63073)	
	0.1670	1.9320**	
AT	-0.0321	0.0274	
	(0.04996)	(0.04512)	
	-0.6420	0.6090	-0.8783
CF	2.1109	2.1839	
	(0.78348)	(0.51819)	
	2.6940*	4.2150*	-0.0807
CE	2.7791	0.6128	
	(0.77218)	(0.49621)	
	3.5990*	1.2350	2.4611*
Adjusted R^2=0.9425			
Two-Stage LS:			
Intercept	695.9345	57.1082	
	(153.25513)	(23.80120)	
	4.5410*	2.3990*	
AT	-0.1155	0.0406	
	(0.03577)	(0.04572)	
	-3.2280*	0.8890	-2.5476*
CF	-0.4466	2.0198	
	(0.61124)	(0.52674)	
	-0.7310	3.8350*	-3.0382*
CE	1.0549	0.4957	
	(0.56541)	(0.49947)	
	1.8660	0.9930	0.7397
Adjusted R^2=0.9721			

Statistic of difference was determined using mean difference test by assuming that the coefficients were random variable drawn from independent population. Choi test can also be used. *Statistically significant at $p < 0.05$.

In the case of FC firms, estimated coefficients are quite different both in sign and significance except for capital expenditure variable. Evaluating the sign and significance, it appears that the OLS consistently overestimates all the explanatory variable coefficients. This means that the OLS will predict higher exploration expenditures after implementation of mandatory method than will the two-stage least square regression. For the case of SE sample, even though all estimates - have the same signs under both methods, only the coefficient of cash flows is significant and it is slightly higher under the OLS. The OLS consistently overestimates the cash flow coefficient by about 8 percent. When the insignificant coefficients are set to zero, the overall overestimation by OLS for full cost and successful efforts firms combined is almost 100 percent.

Table 7 presents predictions of the expected values of exploration expenditures for both successful and full cost samples if they had chosen the alternative method. These average expected values are determined by applying the estimated coefficients from both the switching regression (ignoring the selectivity term) and OLS functions for using data from all FS and SE sample firms. If all firms used the same accounting method before the issuance of SFAS No. 19, the mean value of exploration expenditures predicted by two-stage LS would have been lower under the full cost method (554.19) than under the successful efforts method (877.15). If full cost firms were forced to switch to mandatory method, the mean value of exploration cost would have been greatly higher. Similarly, if SE firms used FC method, the mean value of exploration expenditures would have been higher also. In both cases, the increase is about five times the value under the preferred method. These results suggest that firms choose between accounting methods on the basis of their own characteristics and the relative advantages of each method.

Table 7. Average Expected Value of Exploration Costs if All Firms Were Using the Same Method Before the Release of SFAS No. 19

	Two-stage Regression				OLS Estimates		
	All Firms	*FC Firms*	*SE Firms*		*All Firms*	*FC Firms*	*SE Firms*
$E[EX\|\beta_F]$	554.1924	381.6310	683.2103		1311.1000	2875.7600	141.2514
$E[EX\|\beta_S]$	877.1538	1878.7400	128.3051		894.3302	1950.6700	104.5435

Except for SE firms, the OLS predicts higher exploration expenditures than does the two-stage LS. In contrast to the prediction under two-stage LS, if full cost firms were forced to switch to mandatory method, the mean value of exploration cost would have been lower under the OLS method. However, if SE firms used FC method, the mean value of exploration expenditures would have been higher. In both cases, the decrease and increase in the exploration costs are not as great as those under two-stage LS. Again, these results indicate that firms select an accounting method on the basis of their own characteristics and the relative advantages of each alternative method.

SUMMARY AND CONCLUSION:

This paper examines the suspicion about the presence of self-selection bias in dichotomous data used in major empirical accounting studies investigating the economic consequences of mandatory accounting change. In particular, this paper addresses the selection bias in the data representing oil and gas firms which were classified as full cost and successful efforts adopters. Replicating the procedure used by Shehata (1991), the switching regression analysis indicates the presence of selection bias in the data separating oil and gas firms into both groups. Therefore, correction for this bias is important in the assessment of the effects of SFAS No. 19 on exploration activities. This result confirms the existence of bias in dichotomous data as indicated by Shehata. The switching regression model predicts potential decline in full cost firms' exploration in response to SFAS No. 19 if it were made effective. On the other hand, the OLS consistently overestimates all the explanatory variable coefficients. This means that the OLS will predict higher exploration expenditures after implementation of mandatory method than will the two-stage least square regression.

The results of this paper are subject to some limitations. First, only three variables are used as explanatory variables for criterion and structural functions so that some important factors affecting the results may have been excluded from the model. Second, the sample represents only a specific industry. Therefore, the conclusion in this paper may not be applicable to other industry. Third, this paper does not test the effect of selection bias on the structural changes in the exploration expenditures by comparing the result of both OLS and two-stage LS. Because the standard had not become effective since its withdrawal, there were not enough data on the actual switch of method on the part of FC firms several years immediately after its release or withdrawal. Finally, several values of variables are derived from the data of other study. Malmquist's data are normalized and logged data and the derivation to original values did not take out the normalization effect on the data. Therefore, the results in this paper are affected by any measurement error caused by the incomplete derivation.

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